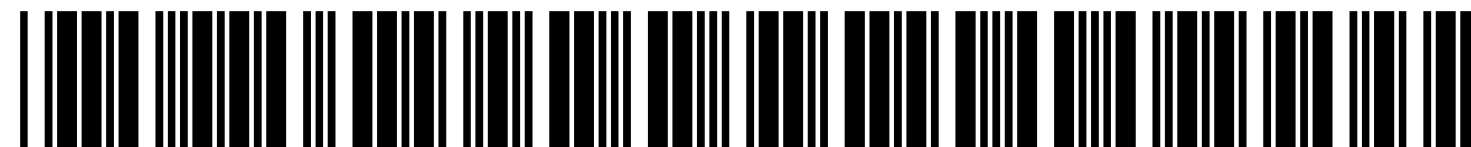
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(12) **United States Patent**
Lassini et al.

(10) **Patent No.: US 10,070,562 B2**
(45) **Date of Patent: Sep. 4, 2018**

(54) **METHOD AND APPARATUS FOR HEAT-DISSIPATION IN AN AVIONICS CHASSIS**

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(*) Notice: Subject to any disclaimer, the term of this patent is extended or adjusted under 35 U.S.C. 154(b) by 8 days.

(21) Appl. No.: **15/156,775**

(22) Filed: **May 17, 2016**

(65) **Prior Publication Data**

US 2017/0339805 A1 Nov. 23, 2017

(51) **Int. Cl.**
H05K 7/20 (2006.01)

(52) **U.S. Cl.**
CPC ***H05K 7/20854*** (2013.01); ***H05K 7/2039*** (2013.01); *H05K 7/20863* (2013.01); *H05K 7/20872* (2013.01)

(58) **Field of Classification Search**
CPC H05K 7/20854; H05K 7/2039; H05K 7/20863; H05K 7/20872
USPC 361/720, 714
See application file for complete search history.

(56) **References Cited**

U.S. PATENT DOCUMENTS

4,396,935 A * 8/1983 Schuck H01L 23/057 174/541
4,867,235 A * 9/1989 Grapes H01L 23/3733 165/185
5,896,272 A 4/1999 Hendrix et al.
6,721,182 B1 * 4/2004 Wells H05K 7/1404 257/727
8,427,828 B2 4/2013 Kehret et al.
8,917,507 B2 12/2014 Nagasawa
2009/0122500 A1 5/2009 Metzger
2010/0319948 A1 12/2010 Vander Ploeg et al.
2010/0321892 A1 * 12/2010 Vander Ploeg H05K 7/1412 361/707
2011/0267776 A1 11/2011 Porreca et al.
2013/0087366 A1 * 4/2013 Michael H01L 23/50 174/252

(Continued)

FOREIGN PATENT DOCUMENTS

CN 103269571 A * 8/2013

OTHER PUBLICATIONS

Extended European Search Report and Opinion issued in connection with corresponding EP Application No. 7171396.9 dated Oct. 16, 2017.

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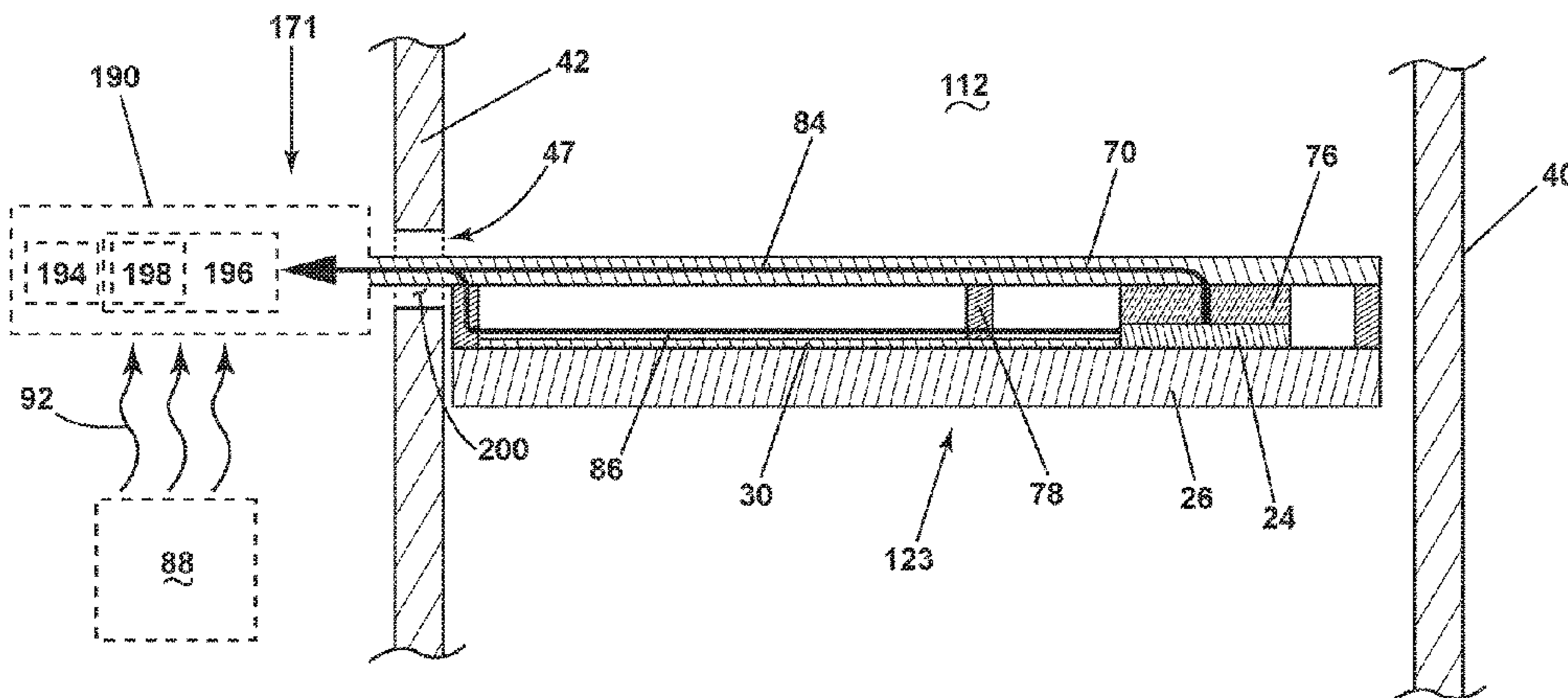
(57) **ABSTRACT**

A method and apparatus for heat-dissipation in an avionics chassis can include a housing having an outer surface, defining an exterior of the housing, an inner surface, defining an interior of the housing, and a set of walls at least partially separating the exterior of the housing from the interior of the housing, a heat generating component located within the interior of the housing, and a thermal plane thermally coupled to the heat generating component and configured to direct heat away from the heat generating component.

15 Claims, 6 Drawing Sheets



(56) **References Cited**

U.S. PATENT DOCUMENTS

2015/0181736	A1	6/2015	de Bock et al.
2015/0201527	A1	7/2015	Stringer et al.

* cited by examiner

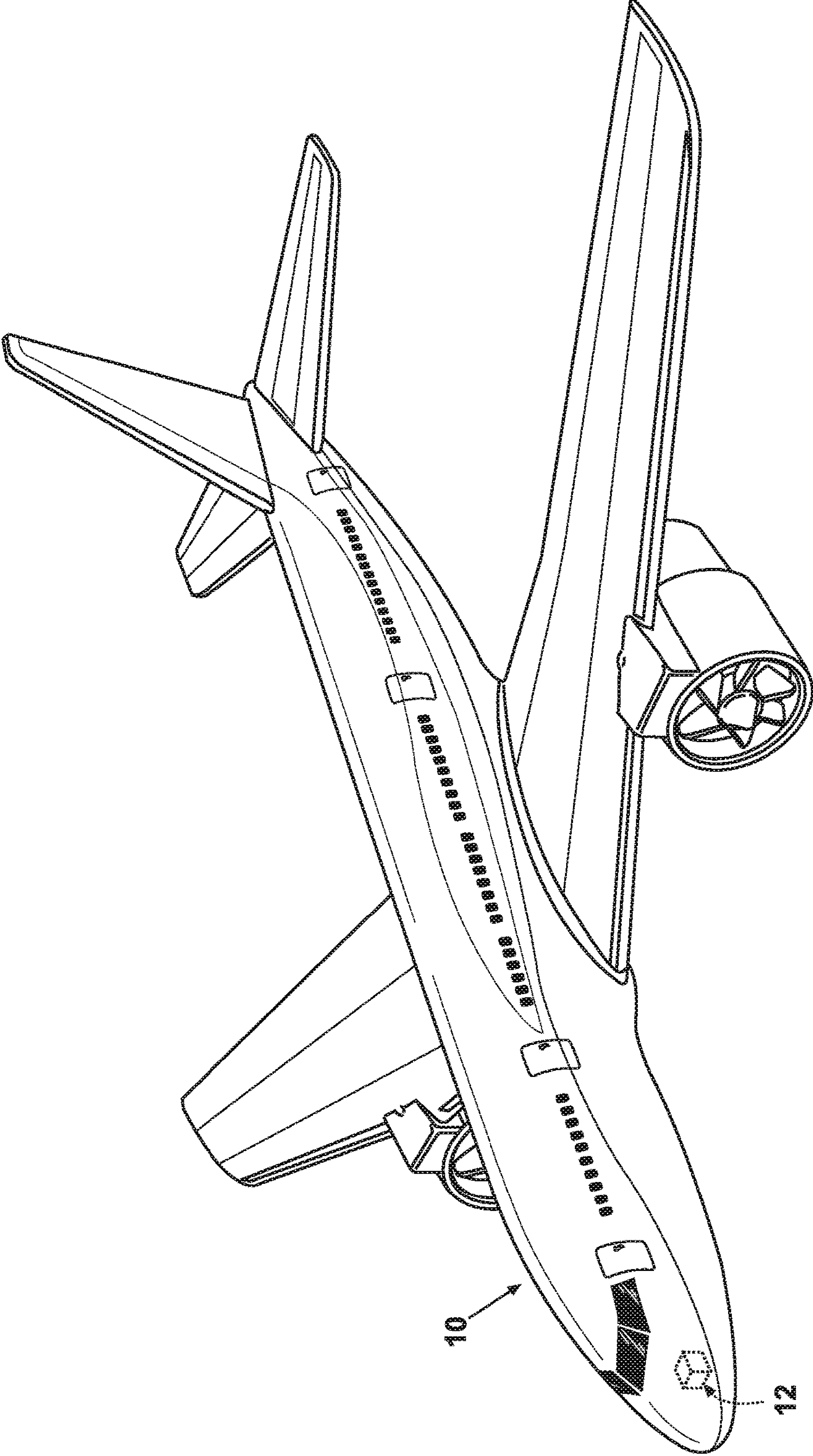


FIG. 1

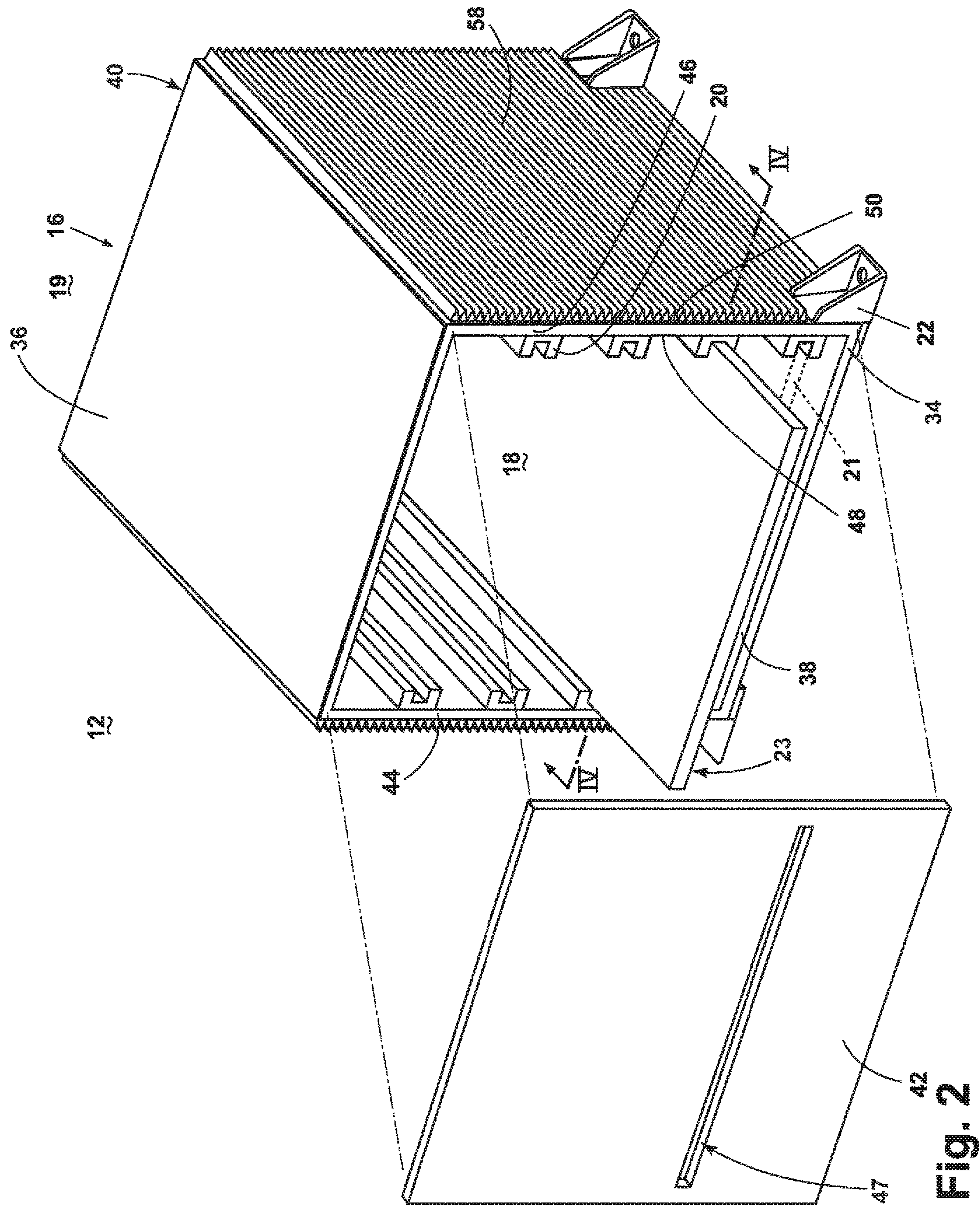


Fig. 2

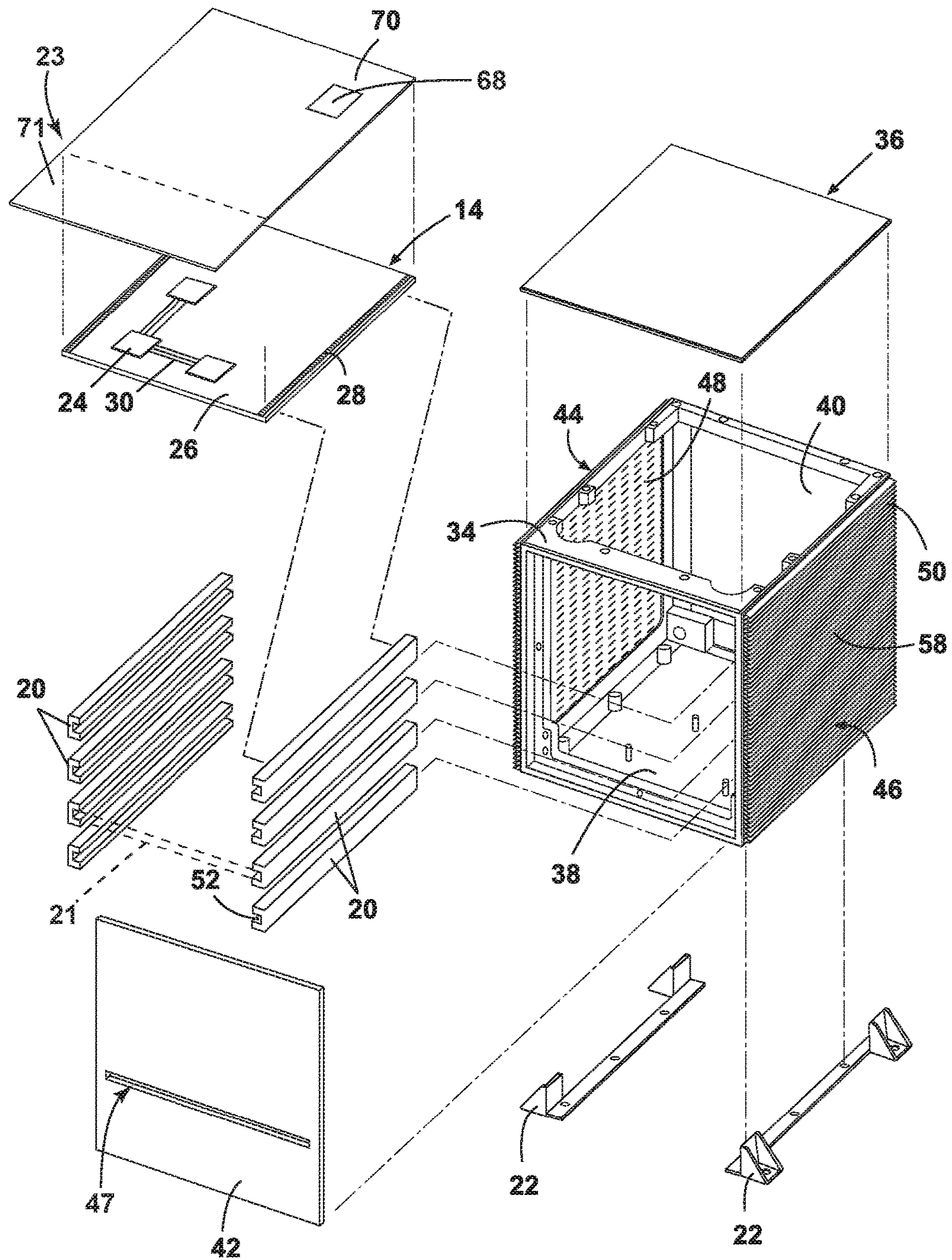


FIG. 3

FIG. 4

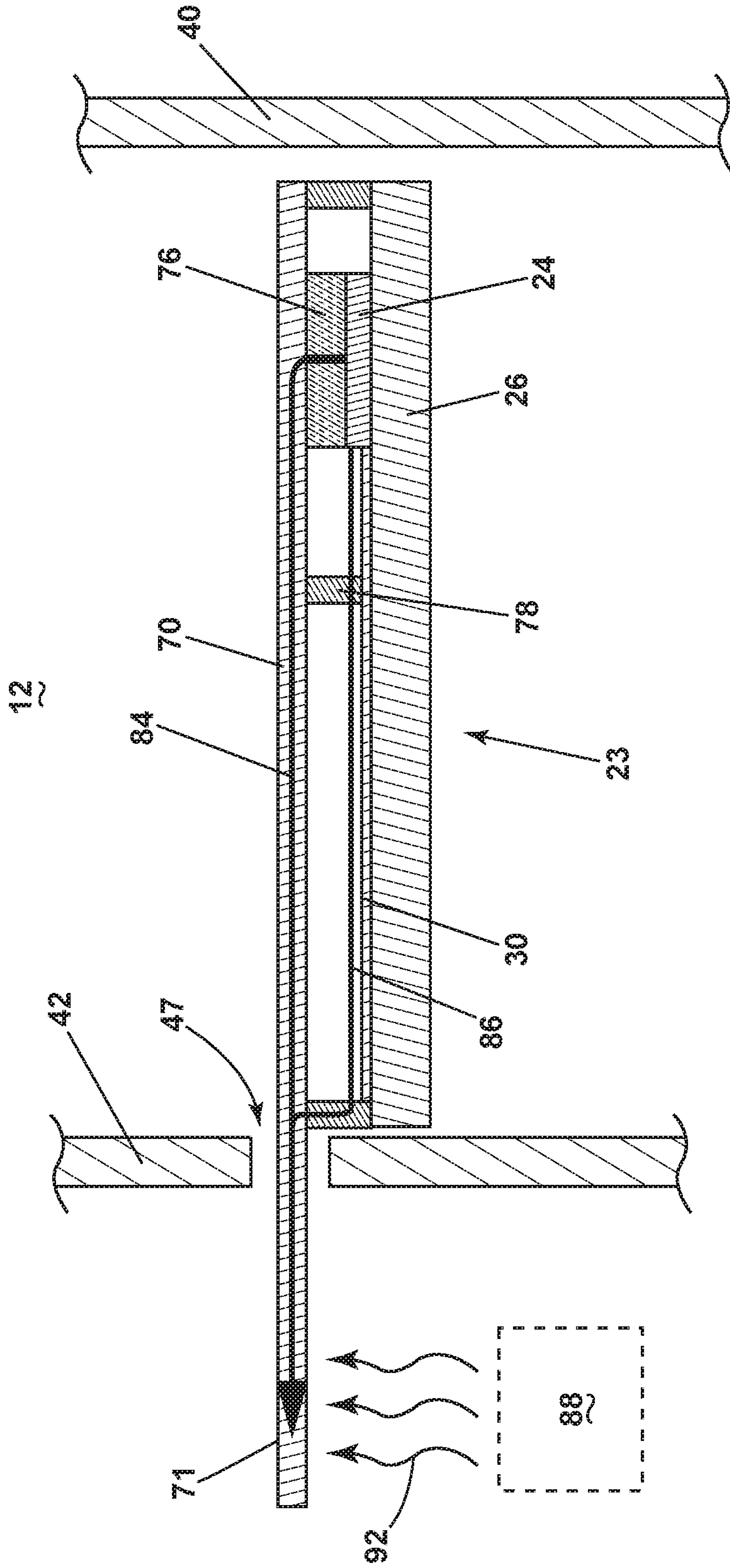


FIG. 5

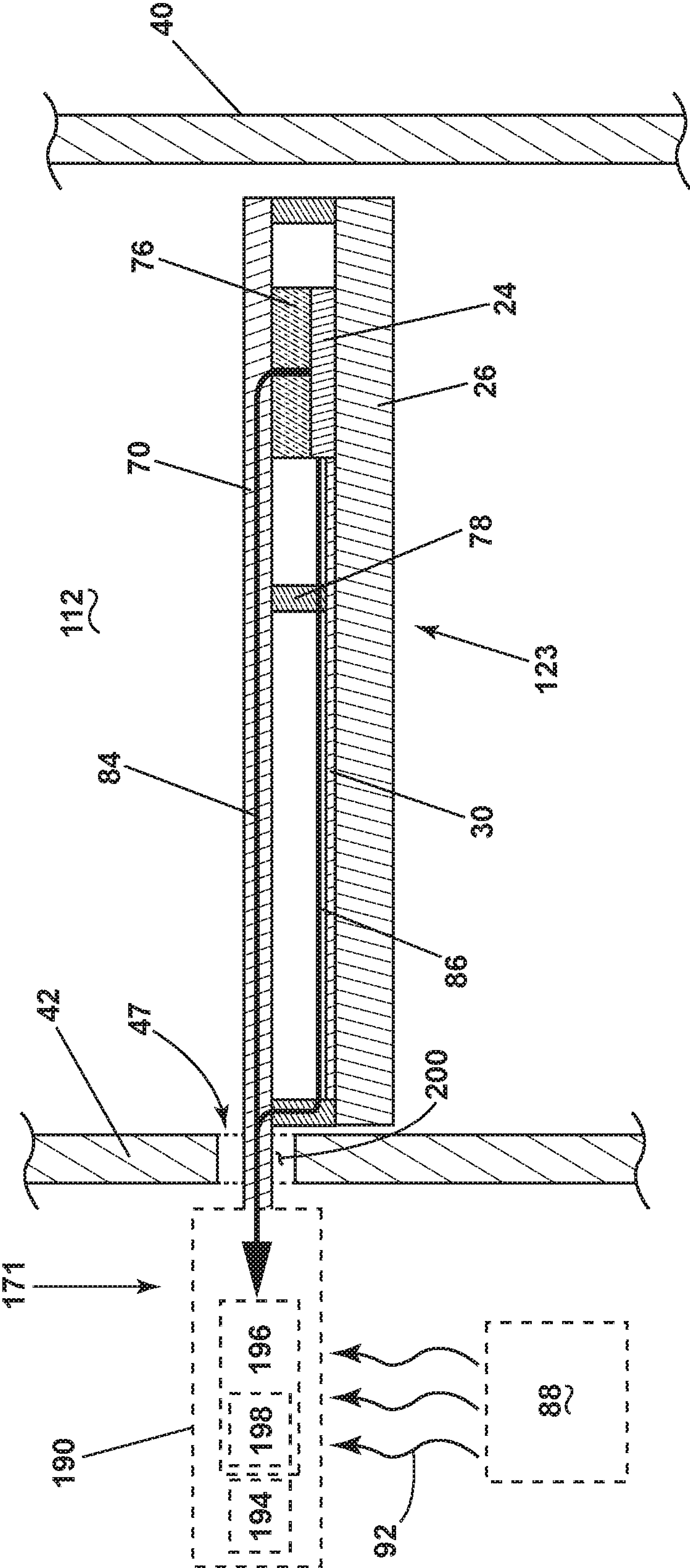


FIG. 6

METHOD AND APPARATUS FOR HEAT-DISSIPATION IN AN AVIONICS CHASSIS

BACKGROUND OF THE INVENTION

Contemporary aircrafts use avionics in order to control the various equipment and operations for flying the aircraft. The avionics can include electronic components carried by a circuit board. The avionics or the circuit boards can be stored in an avionics chassis, which performs several beneficial functions, some of which are: electrically shielding the avionics from electromagnetic interference (EMI), protecting the avionics from lightning strikes, dissipating the heat generated by the avionics or electronic components, and protecting the avionics from environmental exposure.

BRIEF DESCRIPTION OF THE INVENTION

In one aspect, the present disclosure relates to an avionics chassis assembly including a housing having an outer surface, defining an exterior of the housing, an inner surface, defining an interior of the housing, and a set of walls at least partially separating the exterior of the housing from the interior of the housing, a heat generating component located within the interior of the housing, and a thermal plane thermally coupled to the heat generating component and configured to direct heat away from the heat generating component. An opening is included in the housing and the opening is configured to receive at least a portion of the thermal plane such that the at least a portion of the thermal plane passes through the opening and is located exteriorly of the housing to define an extending thermal plane portion.

In another aspect, the present disclosure relates to a heat-dissipating assembly including a housing having a set of planar walls defining an exterior of the housing and an interior of the housing, an electronic circuit board having a heat generating component, where the electronic circuit board is received within the interior of the housing, and a thermal plane in a thermally conductive relationship with the heat generating component and extending from the interior of the housing beyond at least one planar wall into an exterior environment surrounding the housing to define an extending thermal plane portion. The thermal plane is configured to conduct heat away from the heat generating component beyond the at least one planar wall and dissipate at least a portion of the heat to the exterior environment.

In yet another aspect, the present disclosure relates to method of assembling a heat-dissipating assembly, including overlying a thermal plane adjacent a heat producing component such that the heat producing component and the thermal plane are in a thermally conductive relationship, and mounting the thermal plane and the heat producing component within a chassis having a set of planar walls defining an interior of the housing, wherein at least a portion of the thermal plane extends beyond the housing into an exterior environment surrounding the housing to define an extending thermal plane portion.

BRIEF DESCRIPTION OF THE DRAWING

In the drawings:

FIG. **1** is a perspective view of an aircraft having an avionics chassis in accordance with various aspects described herein.

FIG. **2** is a partially exploded perspective view of the avionics in accordance with various aspects described herein, with a cover removed for clarity.

FIG. **3** is an exploded view of the avionics chassis shown in FIG. **2**, in accordance with various aspects described herein.

FIG. **4** is a cross-sectional view taken along the line IV-IV of a portion of the avionics chassis shown in FIG. **2**, in accordance with various aspects described herein.

FIG. **5** is a cross-sectional view taken along the line V-V of a portion of the avionics chassis shown in FIG. **4**, in accordance with various aspects described herein.

FIG. **6** is a cross-sectional view of a portion of the avionic chassis, wherein a thermal plane includes a heat-dissipating configuration, in accordance with various aspects described herein.

DETAILED DESCRIPTION OF THE INVENTION

Aspects of the disclosure describe an approach to utilize an additional portion of a typical conduction cooled circuit card assembly for enhanced thermal dissipation. In typical conduction-cooled avionics, the heat generated by the electronics is collected by heat spreaders of various designs and materials and is conducted to the two sides of the circuit card that mate to the chassis by way of wedge locks. Minimal heat conduction occurs into the back plane, and no heat conduction occurs on the side opposite to the back plane (e.g. the card front). Avionics are constantly challenged with dissipating the heat produced within the electronic components to the environment. The extended range of temperature operation and the ever increasing power density of state of the art designs results in the thermal design of an avionic box becoming one of the main limiting factors in the performance of the system.

While "a set of" various elements will be described, it will be understood that "a set" can include any number of the respective elements, including only one element. Additionally, all directional references (e.g., radial, axial, upper, lower, upward, downward, left, right, lateral, front, back, top, bottom, above, below, vertical, horizontal, clockwise, counterclockwise) are only used for identification purposes to aid the reader's understanding of the disclosure, and do not create limitations, particularly as to the position, orientation, or use thereof. Connection references (e.g., attached, coupled, connected, and joined) are to be construed broadly and can include intermediate members between a collection of elements and relative movement between elements unless otherwise indicated. As such, connection references do not necessarily infer that two elements are directly connected and in fixed relation to each other. The exemplary drawings are for purposes of illustration only and the dimensions, positions, order and relative sizes reflected in the drawings attached hereto can vary.

FIG. **1** schematically illustrates an aircraft **10** with an on-board avionics chassis **12** (shown in phantom) for housing avionics or avionics components for use in the operation of the aircraft **10**. The avionics chassis **12** houses a variety of avionics elements and protects them against contaminants, electromagnetic interference (EMI), radio frequency interference (RFI), vibrations, and the like. While illustrated in a commercial airliner, the avionics chassis **12** can be used in any type of aircraft, for example, without limitation, fixed-wing, rotating-wing, rocket, commercial aircraft, personal aircraft, and military aircraft. The avionics chassis **12** can be located anywhere within the aircraft, not just the nose

as illustrated. Furthermore, aspects of the disclosure are not limited only to aircraft aspects, and can be included in other mobile and stationary configurations. Non-limiting example mobile configurations can include ground-based, water-based, or additional air-based vehicles.

FIG. **2** illustrates the avionics chassis **12** according to an aspect of the present disclosure, with a front cover **42** removed. The avionics chassis **12** includes a chassis housing **16** defining an interior **18** and exterior **19** of the chassis **12**. The avionics chassis **12** can includes a chassis frame **34** having a top cover **36**, a bottom wall **38**, a back wall **40**, and opposing side walls **44**, **46**, collectively referred to as the walls. The frame **34** can further include the aforementioned selectively removable front cover **42**, providing access to the interior **18** of the avionics chassis **12** when removed, and partially restricting access to the interior **18** when coupled or mounted with the frame **34**. The side walls **44**, **46** can include an interior surface **48** and an exterior surface **50**. As shown, a set of heat-dissipating elements, such as fins **58**, can project from the exterior surface **50** of the walls **44**, **46**. While heat-dissipating fins **58** are shown, a number of heat-dissipating elements or heat-dissipating configurations can be utilized by the side walls **44**, **46** to remove or dissipate at least a portion of heat generated by or within the avionics chassis **12**, or heat stored by the avionics chassis **12**.

The avionics chassis **12** can further include a set of thermally conductive card rails **20** within the interior **18** and supported by the interior surface **48** of the side walls **44**, **46**. The set of card rails **20** can be horizontally aligned on the interior surfaces **48** of the spaced on opposing side walls **44**, **46** to define effective card slots **21** (illustrated by the dotted lines) there between for receiving at least a portion of an operable avionics system card **23**. While only a single avionics system card **23** is shown, the avionics chassis **12** can be configured to house, support, or include a set of avionics system cards **23**.

The removable front cover **42** can be selected or configured to include a set of cover openings **47** that can be aligned with a corresponding set of avionics system cards **23** such that when the front cover **42** is coupled or mounted with the frame **32**, at least a portion of the avionics system card **23** can extend from the interior **18** to the exterior **19** of the avionics chassis **12**. Stated another way, the avionics chassis **12** or the avionics system card **23** can be selected or configured such that at least a portion of an avionics system card **23** can extend through a corresponding opening **47** or aperture in the chassis **12** or front cover **42**. In this sense, the opening **47** can be sized, shaped, profiled, or contoured to align or correspond with at least a portion of the avionics system card **23**. While the avionics system card **23** is illustrated extending through an opening **47** in the front cover **42**, aspects of the disclosure can be included wherein the avionics system card **23** is selected, designed, or configured such that at least a portion of the card **23** extends beyond or past a physical or referential plane defined by the avionics chassis **12**, front cover **42**, side walls **44**, **46**, frame **34**, or combination of boundaries thereof.

The avionics chassis **12** is further illustrated including a set of mounting feet **22** extending from the chassis housing **16** to facilitate mounting the avionics chassis **12** to the aircraft **10** by means of bolts or other conventional fasteners. Further, the mounting feet **22**, can function as an electrical ground for grounding the avionics chassis to the frame of the aircraft **10**. While mounting feet **22** are shown in this example the avionics chassis **12** can be used with many types of attachment mechanism.

FIG. **3** illustrates an exploded view illustrating the avionics chassis **12** and avionics system card **23** in more detail. As shown, the avionics system card **23** can include a heat spreader or thermal plane **70** and circuit card assembly, shown as a printed circuit board (PCB) **14** or electronic circuit board. The PCB **14** can further include a substrate **26** supporting or carrying a set of or heat producing components **24**. The PCB **14** or the substrate **26** can further include a set of electrical or thermal conductors **30** interconnecting the set of heat producing components **24**. A non-limiting list of heat producing components **24** can include electrical circuitry, power electronics such as capacitors, transformers, or the like, a semiconductor chip, a processor, memory chips, or the like.

The substrate **26** can include a thermally conductive or non-conductive material. The PCB **14** or substrate **26** can be provided with thermally conductive side strips **28** located along the exterior edges of the PCB **14**. The conductors **30** can be configured to operate or create at least a portion of a thermally conductive path from the heat producing component **24** to an edge of the substrate **26** or PCB **14**, such as to the thermally conductive side strips **28**. In this sense, the conductors **30** can provide a direct thermal pathway from the interior to the periphery of the substrate **26**. The side strips **28** can further provide a thermally conductive interface or pathway to the card rails **20**. The conductors **30** can be one or more metal strips, including, but not limited to, copper or another electrically or thermally conductive material formed in or provided on the substrate **26**.

The thermal plane **70** can be configured in an overlying relationship with the PCB **14**, and can further include an extending thermal plane portion **71** of the thermal plane **70**. The extending thermal plane portion **71** is shown to extend parallel to the longitudinal direction of the side strips **28**, that is, extending in the direction of a front of the PCB **14** or avionics system card **23**, wherein the extending thermal plane portion **71** can be at least partially received by, or extend through the cover opening **47** of the front cover **42** in an assembled avionics chassis **12**. The thermal plane **71** and the extending thermal plane portion **71** can include a thermally conductive material, including but not limited to copper. When the thermal plane **70** and the extending thermal plane portion **71** are assembled with the PCB **14** to form the avionics system card **23**, the planes **70**, **71** are configured to be arranged in a thermally conductive relationship with at least a subset of the heat producing components **24**, the conductors **30**, or the side strips **28**. In this sense, heat generated or produced by at least a subset of operable heat producing components **24** can be thermally conducted to the overlying thermal plane **70**, which the heat can be further thermally conducted to the side strips **28**, to the extending thermal plane portion **71**, or a combination thereof.

The illustration of the thermal plane **70** and the extending thermal plane portion **71** indicates the plane **70** and plane portion **71** are separated by a dotted line for understanding. Aspects of the disclosure can be included wherein the thermal plane **70** and extending thermal plane portion **71** are a single integral plane, or are separate planes thermally coupled to one another. In one non-limiting example configuration, the cover opening **47** can be configured to receive only the thermal plane **70** or the extending thermal plane portion **71**. In another non-limiting example configuration, the front cover **42** can include a set of cover openings **47** configured or selected to receive a corresponding set of thermal planes **70** or extending thermal plane portions **71**.

Aspects of the disclosure can be included wherein the extending thermal plane portion **71** can be configured in an overlying relationship with the PCB **14**, such as a PCB **14** also having an extending portion, or the extending thermal plane portion **71** can be configured to extend beyond the relationship with the PCB **14**. Aspects of the disclosure can also be included wherein the thermal plane **70** or the extending thermal plane portion **71** can include discontinuities, such as gaps, holes, or cutouts **68**. For example, a cutout **68** can be included to reduce materials, so long as the cutout **68** does not inhibit the thermally conductive relationship of the respective plane **70**, **71** with the heat producing component **24** or conductor **30**.

The set of card rails **20** for the avionics chassis **12** can be configured to abut the interior surface **48** and can be fixedly mounted thereto. The set of card rails **20** can be attached to the interior surface **48** using any convenient method such as mechanical fasteners, solders, brazes, welds, adhesives, and the like. Aspects of the card rail **20** can be configured to include two legs that define a groove or channel **52**, extending along the length of the side walls **44**, **46** (e.g. from front to back, or between the front cover **42** and the back wall) which partially defines the slot **21** for receiving the avionics system card **23**. The set of card rails **20** can be arranged in pairs, with one card rail **20** residing on the side wall **44** and a corresponding card rail **20** residing on the side wall **46**. Parallelism between the pair of card rails **20** can be utilized to ensure that the PCB **14** or the avionics system card **23** will slide into the slot **21** or channel **52** properly. The interaction of the pair of card rails **20** and the PCB **14** or the avionics system card **23** can be referred to as "wedge locks." The card rails **20** can be made of any suitable thermally conductive material including either machined or extruded aluminum, copper, aluminum/beryllium alloy, machined silicon carbide or a metal matrix composite. Aspects of the disclosure can further be included wherein the attachment of the set of card rails **20** to the side walls **44**, **46** include a thermally conductive relationship, such that the set of card rails **20** are thermally coupled with at least one of the side walls **44**, **46**, the avionics chassis **12**, or the heat-dissipating fins **58**.

FIG. **4** illustrates a cross-sectional view of a portion of the assembled avionics chassis **12** taken along line IV-IV of FIG. **2**, including an avionics system card **23** mounted between opposing side walls **44**, **46** and card rails **20**. As shown, the PCB **14** defines a first primary plane, the thermal plane **70** defines a second primary plane, and the spatial relationship between the PCB **14** and the thermal plane **70** is such that the first and second primary planes are located within the slot **21** when the avionics system card **23** is received within the slot **21**. In another aspect of the disclosure, the PCB **14** or the thermal plane **70** can be configured such that the spatial relationship between the PCB **14** and the thermal plane **70** are such that the first primary plane, the second primary plane, or a combination thereof, are not completely within the envelope of one slot **21** when the avionics system card **23** is received within the slot **21** or received between the set of card rails **20**.

As shown, the avionics system card **23**, the PCB **14**, or the thermal plane **70** can further include an optional thermal pad **76** or a set of stiffeners **78**. The optional thermal pad **76** can include a thermally conductive material, such as a carbon composite, a metal or a thermally conductive paste, and can be positioned in thermally conductive contact with a heat producing component **24** and the thermal plane **70** of an assembled avionics system card **23**. Alternatively, the thermal plane **70** can be directly thermally coupled with the heat producing component **24**. The optional set of stiffener **78** can be located between the PCB **14** and the thermal plane **70** when the avionics system card **23** is located within the slot **21**. In one aspect of the disclosure, the set of stiffener **78** can be operably coupled to the PCB **14** so that the PCB **14** will not flex or vibrate within the slot **21**. In another aspect of the disclosure, the set of stiffeners **78** can be configured to set or maintain a predetermined spacing or range of spacing between the PCB **14** and the thermal plane **70**. The stiffener **78** can be included of aluminum or similar thermally conductive material and can have a variety of configurations to provide support for the PCB **14**. Yet another aspect of the disclosure can include any suitable shape, composition, or configuration of a set of stiffener **78** for the avionics card assembly. In yet another aspect of the disclosure, at least one of the set of stiffeners **78** or the thermal pad **76** can be integral to, or include the same material as the thermal plane **70** or the PCB **14**.

When the avionics system card **23** is assembled in the slot **21**, the thermal plane **70** can be conductively coupled to at least one of the set of card rails **20** to form a portion of a first conductive path **72**. The PCB **14** can further be conductively coupled to the same or another of the set of card rails **20** to form a portion of a second conductive path **74**. The first conductive path **72** begins with the heat-producing component **24**; heat is conducted through the thermal pad **76** to the thermal plane **70**, which in turn conducts that heat laterally to the card rails **20**. The first conductive path **72** continues through the card rails **20** to either the side walls **44**, **46** themselves, or to an additional heat-dissipating components such as the fins **58**. In an aspect of the disclosure, heat can be conducted first to a side wall **44**, **46**, then to an additional heat-dissipating component. Heat can be dissipated through at least one of the side walls **44**, **46**, or heat-dissipating components into the air or environment surrounding the avionics chassis **12** by way of convection or radiation.

The second conductive path **74** begins with the heat-producing component **24**; heat is then transferred through the conductors **30** of the PCB **14** to the set of thermally conductive side strips **28**. Although the arrows illustrated in FIG. **4** are offset from the conductors **30**, this is done for illustrative purposes and the conductors **30** are actually a portion of the second conductive path **74**. The arrow has merely been offset so that it does not obscure the conductors **30** in the illustration. The set of side strips **28** can the card rail **20** and heat, in turn, conducts from the card rail **20** either through the side walls **44**, **46** themselves, or to an additional heat-dissipating components such as the fins **58**. As with the first conductive path **72**, in an aspect of the disclosure, heat traversing the second conductive path **74** can be conducted first to a side wall **44**, **46**, then to an additional heat-dissipating component. Heat can be dissipated through at least one of the side walls **44**, **46**, or heat-dissipating components into the air or environment surrounding the avionics chassis **12** by way of convection or radiation. Thus, the PCB **14** also acts as a heat spreader by itself. This allows the avionics chassis **12** to run much cooler with the additional conductive path provided by the thermal plane **70**.

As shown, the height of the PCB **14** can be configured such that the PCB **14** and the thermal plane **70** are both received within the channel **52**. Also as shown, the PCB **14** can be configured to be in direct contact with the main portion of the card rail **20**. The thermal plane **70** can also be configured to be in direct contact with a leg of the card rail **20** and in direct contact with the main portion of the card rail **20**. Alternatively, the contact between the PCB **14** and the set of card rails **20** or the contact between the thermal plane **70** and the set of card rails **20** could be indirect contacts.

While the thermal plane **70** is shown attached to the top of the PCB **14** (e.g. overlying), aspects of the disclosure can be included wherein the thermal plane **70** is attached below the PCB **14** (e.g. underlying). In this other aspect of the disclosure, the heat generating components **24** can be positioned between the substrate **26** and the thermal plane **70**, or the thermal plane **70** can directly or indirectly abut the substrate such that heat can be conducted through the substrate to the thermal plane **70**.

FIG. **5** illustrates a cross-sectional view of a portion of the assembled avionics chassis **12** taken along line V-V of FIG. **4**, including an avionics system card **23** mounted between the back wall **40** and the front cover **42**, and wherein at least a portion of the extending thermal plane portion **71** extends beyond, or protrudes through the opening **47** of the front cover **42**. The illustration further illustrates a third conductive path **84** and a fourth conductive path **86**.

The third conductive path **84** begins with the heat-producing component **24**; heat is conducted through the thermal pad **76** to the thermal plane **70**, which in turn conducts that heat laterally to the extending thermal plane portion **71**, which is external to the avionics chassis **12**. Heat can then be dissipated into the air or environment surrounding the avionics chassis **12** by way of convection or radiation. In one aspect of the disclosure, the heat can be removed from the extending thermal plane portion **71** through passive conduction or radiation to the environment. In another aspect of the disclosure, the heat can be removed from the extending thermal plane portion **71** by an external cooling system **88**, which can be configured to provide an active cooling medium **92** to the extending thermal plane portion **71** external to the avionics chassis **12**. Non-limiting examples of an external cooling system **88** and active cooling medium **92** can include a fan providing forced air to at least a portion of the extending thermal plane portion **71**, or a liquid cooling circuit providing liquid coolant to at least a portion of the extending thermal plane portion **71**. In the non-limiting example of liquid cooling, a liquid coolant reservoir can be fluidly coupled with a set of coolant channels arranged within the extending thermal plane portion **71**, such that the liquid coolant can be forced or pumped through the channels to define a liquid cooling circuit. Additional external cooling systems **88** can be included.

The fourth conductive path **86** begins with the heat-producing component **24**; heat is then transferred through the conductors **30** of the PCB **14** to the thermal plane **70**, for instance, by way of a thermally conductive stiffener **78**. Again, although the arrows illustrated in FIG. **5** are offset from the conductors **30**, this is done for illustrative purposes and the conductors **30** are actually a portion of the second conductive path **74**. The thermal plane **70** conducts the heat laterally to the extending thermal plane portion **71** external to the avionics chassis **12**. The heat conducted to the extending thermal plane portion **71** external to the avionics chassis **12** can then be actively or passively removed to the surrounding environment, as explained above.

Thus, aspects of the disclosure describe an avionics chassis having a portion of a thermal plane extending beyond the chassis, and wherein heat generated by a heat generating component can be dissipated outside of the chassis by way of the thermal plane. The heat dissipation by way of the thermal plane extending external to the chassis can provide supplemental thermal dissipation, or can replace existing thermal dissipation by way of the set of card rails **20** or side walls **44**, **46**. This allows the avionics chassis **12** to run much cooler with the additional conductive paths provided by the thermal plane **70** and the extending thermal plane portion **71**.

FIG. **6** illustrates another avionics chassis **112** according to another aspect of the present disclosure. The avionics chassis **112** is similar to the avionics chassis **12**; therefore, like parts will be identified with like numerals increased by 100, with it being understood that the description of the like parts of the avionics chassis **12** applies to the avionics chassis **112**, unless otherwise noted. One difference is that the extending thermal plane portion **171** of the avionics system card **123** includes an additional heat-dissipating configuration (shown schematically as box **190**) external to the avionics chassis **112**. Non-limiting aspects of the heat-dissipating configuration can include heat-dissipating fins, heat-dissipating pin fins, heat pipes, thermally conductive inlays, or apertures or channels to allow coolant fluid flow to traverse through or proximate to the extending thermal plane portion **171**. Thus, as described herein, a set of heat dissipating configurations or heat spreaders of various designs, constructions, and thermally conductive or thermally dissipative materials can be included. The heat-dissipating configuration **190** can be configured to increase the exterior surface area of the extending thermal plan portion **171** allowing more heat to be transferred to the surrounding air through convection.

The enhanced heat spreader or thermal plane **70** further retains all the avionics chassis **12** and avionics system card **23** mating features, including typical wedge locks, so that it can be fitted or retrofitted in a standard chassis **12**. The wedge lock heat conduction path (e.g. the first and second conductive paths) remains available, while being supplemented by a solid conduction path (e.g. the third and fourth conductive paths) directly to the environment or to the chosen heat exchanger mechanism. The heat exchanger portion can be built in various heights and thicknesses to provide varying degrees of additional heat dissipation capabilities while retaining compatibility with standard avionics system card **23** pitches.

Configurations can be included wherein one or more of the heat-dissipating configuration(s) **190** can be parallel to, offset from, or normal to the planar surface of the thermal plane **70**. In another aspect, the heat-dissipating configuration **190** can include a first heat-dissipating configuration on the top portion of the configuration **190**, and a second heat-dissipating configuration on the bottom portion of the configuration **190**. The corresponding top or bottom heat-dissipating configurations can be configured or selected based on an expected or desired heat-generation of the heat producing component **24**, thermal plane **70**, or avionics system card **23**, **123**. In another aspect of the disclosure, the heat-dissipating configuration **190** can be selected or configured based on expected or desired heat-dissipating characteristics of the heat producing component **24**, thermal plane **70**, or avionics system card **23**, **123**.

In yet another aspect, the heat-dissipating configuration **190** can be selected or configured based on external environment characteristics or an available external cooling system **88**. In one non-limiting example, if a forced air stream is available as a portion of an external cooling system **88**, the heat-dissipating configuration **190** can include a set of fins or pin fins (schematically shown as box **194**) configured to receive and thermally interact with the forced air stream.

In another aspect, the heat-dissipating configuration **190** can include a housing (schematically shown as box **196**) configured to hold a phase-change material (schematically

shown as box **198**). The phase change material can include, but is not limited to, paraffin wax, a solid which changes phase to a liquid when sufficient heat is absorbed, and further changes phase from a liquid back to a solid when sufficient heat is released. A typical melting point of paraffin wax is between 46 and 68 degrees Celsius. After the phase change from solid to liquid, the paraffin wax is able to further absorb supplementary heat, beyond the heat causing the phase change to occur. The paraffin wax is configured to repeatedly change phase from a solid to a liquid, and back to a solid, reliably for multiple cycles. Other phase change materials, including but not limited to ammonia, can be included, so long as the material changes phase from a starting phase to at least one different phase in response to the conductive transfer of heat. The starting phase and at least one different phase can be one of solid, liquid, and gas.

Thus, the phase-change material can reliably store or absorb a first amount of heat from the thermal plane **70** and melt from a solid to a liquid. The phase-change material can further reliable store or absorb a second amount of heat from the thermal plan **70** in liquid form as well. The heat stored or absorbed by the phase-change material can then be dissipated over a period of time to the external environment, or by way of the aforementioned heat-dissipating configurations **190**. The first and second amounts of heat can originate from the heat producing component **24** during normal operation, or can originate from the heat producing component **24** during a temporary or transient time of high-energy or high-heat-producing operations, or during a loss of cooling system **88** operations.

In yet another aspect, at least a portion of the heat-dissipating configuration **190** can include carbon black material to increase the convection of heat to the external environment.

Furthermore, since the extending thermal plane portion **71**, **171** is not physically restrained or constrained by the internal volume of the avionics chassis **12**, **112**, aspects of the heat-dissipating configuration **190** can include heat-dissipating elements configured in a non-parallel direction, relative to the thermal plane **70**. In one non-limiting example, a heat-dissipating configuration **190** can include a set of heat-dissipating elements arranged in parallel with the front cover.

In yet another aspect, the extending thermal plane portion **71**, **171** can be a separate element from the thermal plane **70**, and can be mounted or thermally coupled with the thermal plane **70**. In this sense, the avionics chassis **12**, **112** can be assembled without the extending thermal plane portion **71**, **171**, which can be mounted to the thermal plane **70** through the opening **47**. In another non-limiting configuration, a thermal plane **70**, separate from the extending thermal plane portion **71**, **171**, can extend through the opening **47** during assembly, such that the extending thermal plane portion **71**, **171** can be mounted with the thermal plane **70** from the exterior **19** of the avionics chassis **12**. In this sense, aspects of the disclosure can be included in existing avionics system cards **23**, **123**, or retro-fitted to be included in existing avionics system cards **23**, **123**, by including the extending thermal plane portion **71**, **171** and an opening **47** in the front cover **42**.

In yet another aspect, the front cover, the opening **47**, the thermal plane **70**, or the extending thermal plane portion **71** can include environmental or electromagnetic interference seals **200** to ensure environmental compatibility within the interior **18** of the avionics chassis **12**.

Non-limiting aspects of the disclosure can include a method of assembling a heat-dissipating assembly for the avionics chassis **12**, **112**. For example, the method can include selecting a thermal plane **70**, **71**, **171** for overlying the heat producing component **24**. The method can also include overlying the thermal plane **70**, **71**, **171** adjacent to the heat producing component **24** such that the heat producing component **24** and the thermal plane **70**, **71**, **171** are in a thermally conductive relationship. Then, the method can include mounting the thermal plane **70**, **71**, **171** and the heat producing component **24** within a housing, such as the avionics chassis **12**, having a set of planar walls defining an interior **18** of the housing and an exterior **19** of the housing. At least a portion of the thermal plane **70**, **71**, **171** can extend from the interior **18** of the housing beyond at least one of the planar walls, such as the front cover **42**, to the exterior **19** environment surrounding the housing. At least one of the thermal plane **70**, **71**, **171** or the planar wall can be selected based on retro-fitting an existing avionics chassis **12**, avionics system card **23**, or heat producing component **24**.

The aspects of the present disclosure provide a heat-dissipating configuration for an avionics system card or heat producing component. The technical effect is that the aspects described herein enable the cooling of said heat producing component by way of laterally conducting at least a portion of heat generated to a thermal plane portion forwardly extending past the avionics chassis or housing. One advantage that can be realized is superior cooling capabilities compared with conventional systems. Thus, even during expected environmental conditions and diurnal cycles, a thermal plane can dissipate heat generated by a heat producing component.

By increasing the heat-dissipation, a higher power density can be achieved in the same avionics system card or constrained space. An increased power density allows for increased computational power or increased sensor or emitter power supported within the physically-constrained space, weight-constrained space, or volume-constrained space. Yet another advantage is that thermal plane configurations allow for the retro-fitting of additional capabilities within existing avionics chassis, or the design of a new system with power densities not currently achievable using convention thermal dissipation configurations.

Many other possible configurations in addition to that shown in the above figures are contemplated by the present disclosure. In one non-limiting example, while the front cover has been described as including the opening, any of the walls of the chassis can be configured to include the opening such that the extending thermal plane portion is received through the opening. To the extent not already described, the different features and structures of the various aspects can be used in combination with others as desired. That one feature cannot be illustrated in all of the aspects is not meant to be construed that it cannot be, but is done for brevity of description. Thus, the various features of the different aspects can be mixed and matched as desired to form new aspects, whether or not the new aspects are expressly described. Combinations or permutations of features described herein are covered by this disclosure.

This written description uses examples to disclose aspects of the invention, including the best mode, and also to enable any person skilled in the art to practice aspects of the invention, including making and using any devices or systems and performing any incorporated methods. The patentable scope of the invention is defined by the claims, and can include other examples that occur to those skilled in the art. Such other examples are intended to be within the scope of the claims if they have structural elements that do not differ from the literal language of the claims, or if they include

equivalent structural elements with insubstantial differences from the literal languages of the claims.

What is claimed is:

1. An avionics chassis assembly, comprising: a housing having an outer surface, defining an exterior of the housing, an inner surface, defining an interior of the housing, and a set of walls at least partially separating the exterior of the housing from the interior of the housing; a heat generating component located within the interior of the housing; a thermal plane thermally coupled to the heat generating component and configured to direct heat away from the heat generating component; and an electronic circuit board wherein the heat generating component is mounted to the electronic circuit board, wherein an opening is included in the housing and the opening is configured to receive at least a portion of the thermal plane such that the at least a portion of the thermal plane passes through the opening and is located exteriorly of the housing to define an extending thermal plane portion, wherein the thermal plane overlies the electronic circuit board, and wherein the extending thermal plane portion comprises electromagnetic interference seals to ensure environmental compatibility with the interior of the housing; and wherein the housing comprises a selectively removable front cover, wherein the opening is located within the front cover, and wherein the opening comprises a laterally-extending slot.

2. The avionics chassis assembly of claim **1** wherein the opening is sealed about the thermal plane.

3. The avionics chassis assembly of claim **1** wherein the extending thermal plane portion comprises a heat-dissipating configuration.

4. The avionics chassis assembly of claim **3** wherein the heat-dissipating configuration comprises at least one of a set of fins, a set of pin fins, a set of heat pipes, a set of thermally conductive inlays, or carbon black material.

5. The avionics chassis assembly of claim **3**, further comprising an external cooling system providing a forced air stream to the heat-dissipating configuration.

6. The avionics chassis assembly of claim **5** wherein the heat-dissipating configuration comprises channels configured to receive a cooling fluid from the external cooling system.

7. The avionics chassis assembly of claim **6** wherein the heat-dissipating configuration comprises a phase-change material.

8. The avionics chassis assembly of claim **7** wherein the phase-change material comprises paraffin wax.

9. The avionics chassis assembly of claim **1** wherein the thermal plane is configured to conduct heat laterally along the thermal plane to an extending thermal plane portion.

10. A heat-dissipating assembly, comprising:

a housing having a set of planar walls defining an exterior of the housing and an interior of the housing, the housing having one or more openings;

an electronic circuit board comprising a heat generating component, where the electronic circuit board is received within the interior of the housing; and

a thermal plane in a thermally conductive relationship with the heat generating component and extending from the interior of the housing through the one or more openings beyond at least one planar wall of the set of planar walls into an exterior environment surrounding the housing to define an extending thermal plane portion;

wherein the thermal plane is configured to conduct heat away from the heat generating component beyond the at least one planar wall and dissipate at least a portion of the heat to the exterior environment,

wherein the portion of the thermal plane in the interior of the housing is coplanar with the extending thermal plane portion,

wherein the at least one planar wall comprises an opening receiving the extending thermal plane portion, and

wherein the opening comprises a laterally-extending slot.

11. The heat-dissipating assembly of claim **10** wherein at least a portion of the extending thermal plane portion includes at least one of a set of fins, a set of pin fins, a set of heat pipes, a set of thermally conductive inlays, carbon black material, a set of coolant channels, or a phase-change material.

12. The heat-dissipating assembly of claim **10** wherein the thermal plane and the extending thermal plane portion are integral with each other.

13. A method of assembling a heat-dissipating assembly, comprising:

overlying a thermal plane adjacent a heat producing component such that the heat producing component and the thermal plane are in a thermally conductive relationship;

mounting the thermal plane and the heat producing component within a chassis having a set of planar walls defining an interior of the housing;

mounting a cover comprising an opening for receiving the extending thermal plane portion to the chassis; and

providing one or more openings in the set of planar walls,

wherein at least a portion of the thermal plane extends beyond the housing through the one or more openings in the set of planar walls into an exterior environment surrounding the housing to define an extending thermal plane portion.

14. The method of claim **13** wherein overlying, mounting within the chassis, and mounting the cover comprise retrofitting an existing chassis or an existing heat producing component.

15. The method of claim **14** wherein the thermal plane includes a heat-dissipating configuration, and

wherein the thermal plane comprises a thermally conductive material comprising at least one of copper and an aluminum beryllium alloy.

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